Remarks/Arguments

In the specification, paragraph [0057] is amended to correct a typographical error.

In the Office Action, dated October 24, 2003, the examiner rejected claim 85 under 35 U.S.C. §§ 102(b) and 103(a) as being anticipated by, and obvious over, Kuznetsov; he rejected claims 151 and 166 under 35 U.S.C. §§ 102(b) and 103(a) as being anticipated by, and obvious over, Yamamoto et al., JJAP '99; and he rejected claims 144, 160, and 173 under 35 U.S.C. §§ 102(b) and 103(a) as being anticipated by, and obvious over, Yamada et al., NIMB '93. The examiner also allowed claims 2-28, 30, 32-78, 80-84, 106-119, 122-132, 134, 135, 137-143, 147-150, 156, 159, 162-165, 167-172, and 174-180, and he objected to claims 89-105, 145, 152-155, and 161, but indicated that those claims would be allowable if rewritten to not depend from rejected claims, etc. Please note that, while claim 166 was included by the examiner in the list of allowed claims, it was also specifically rejected by the examiner. Therefore, applicant surmises that inclusion of claim 166 in the list of allowed claims may have been an oversight and is treating claim 166 as a rejected claim in this response.

Re: Claim 85:

As noted by the examiner, claim 85 was previously amended to recite, *inter alia*:

> an active layer of GaP that is modified by isoelectronically co-doping the GaP with sufficient concentrations of N and Bi to comprise GaP:N:Bi ***with a lower effective bandgap in the range of about 1.55 eV to 1.93 eV*** . . . . (emphasis added)

The examiner is mistaken in his current assertion that Kuznetsov teaches a similar bandgap. On the contrary, page 417 and Figure 1, as well as Figures 2-5, of Kuznetsov show ***only separate and distinct*** N, NN, Bi, and Bi-Si impurity photoluminescence and electroluminescence emissions at various ***distinct*** energy levels, which clearly ***do not*** create an

effective bandgap for the GaP:N:Bi of anything lower than its normal low temperature bandgap of 2.35 eV, let alone lower it to anything even close to the range of the 1.55 eV to 1.93 eV recited in claim 85. This distinction goes to the crux of this invention, which is simply not shown or fairly suggested in any way by Kuznetsov or by any other prior art reference.

The examiner may have mistaken the distinct N, NN, Bi, and Bi-Si impurity emissions (designated A^N, NN, A^{Bi}, Bi-Si, respectively) and their associated longitudinal optic (LO) phonon replicas (designated A-LO, A^1-LO, etc.) in Kuznetsov's Figure 1 as indications of an effective bandgap for Kuznetsov's GaP:Bi:N material. They are not. As shown by the recent article by Zhang et al. (Exhibit 2 to the Rule 132 Declaration of Angelo Mascarenhas, Ph.D., submitted herewith), it is only at concentrations of N that are orders of magnitude above those used by Kuznetsov that the impurity energy levels induced by the electron traps and hole traps actually merge with the GaP bandgap, i.e., are no longer distinct, to lower the effective bandgap of the GazP:N:Bi alloy itself, as opposed to the distinct N, Bi, NN, Bi-Si, etc., energy emission levels shown in Kuznetsov. The Kuznetsov Figures 1-4 show the distinct emission energy levels of the isolated N, NN, Bi, and Bi-Si impurities as well as their associated distinct longitudinal optic (LO) phonon replicas (specifically designated as A^N, NN_1, A^{Bi}, Bi-Si, A-LO, etc.), but they do not show any radiative recombinations across the GaP host lattice bandgap, i.e., GaP recombinations across the GaP host lattice bandgap. Therefore, there is nothing in Kuznetsov to indicate any bandgap associated with the GaP host lattice other than the 3.35 eV± 0.002 eV mentioned by Kuznetsov on page 117, column 2, last paragraph.

Further, Kuznetsov, himself, makes it very clear that his strong, room temperature emission in the orange part of the spectrum, which peaks at 1.96 eV, is only a Bi emission. It is not indicative in any way of a GaP:N:Bi effective bandgap. For example, Kuznetsov Figures 2

and 3 show two ***distinct*** electroluminescence peaks---Bi at 1.96 eV (orange) and N at about 2.2 eV (green) (see Kuznetsov page 419, column 1). These Bi and N peaks in Kuznetsov would not be distinct, if the valence and conductive energy bands of the GaP host lattice had merged with the energy levels associated with the respective hole traps and electron traps created by the Bi and N, as taught by this invention.

Therefore, contrary to the examiner's assertion, Kuznetsov does not teach, show, or suggest in any way the present claimed invention of modifying GaP with N and Bi to achieve any lower effective bandgap of the resulting GaP:N:Bi, let alone lowering it to the range of 1.55 eV to 1.93 eV. Kuznetsov merely demonstrates individual, distinct emissions from Bi, N, and other impurities in the host GaP, not radiative recombination across the GaP bandgap. Therefore, applicant's claim 85 is neither anticipated by, nor obvious over, Kuznetsov. Consequently, the examiner is requested to withdraw his rejection of claim 85 based on 35 U.S.C. § 102(b) and/or 35 U.S.C. § 103(a), and to allow this claim 85 as currently presented.

Please note that claim 85 is also amended to provide the definite article --the-- before "GaP" in line 2 to alleviate ambiguity.

Re: Claims 151 and 166:

Applicant's claim 151 recites, *inter alia*, modifying a Group II-VI semiconductor compound or alloy by ***isoelectronically co-doping*** the semiconductor compound or alloy with a ***first isoelectronic dopant*** and a ***second isoelectronic dopant***. Similarly, claim 166 recites a ***first isoelectronic dopant*** and a ***second isoelectronic dopant*** in a Group II-VI semiconductor compound or alloy.

Isoelectronic dopants are in ***the same Group*** (i.e., column) in the Periodic Table as the cations or anions of the host lattice, thus they have the ***same number of valence electrons*** as the

host elements they replace (i.e., are isovalent). Yamamoto et al., ***does not*** show or teach ***isoelectronic doping***. On the contrary, ***none of the Al, Ga, In, or N dopants used in Yamamoto et al.*** is in either Group II or Group VI, i.e., they ***are not isoelectronic***. Therefore, the examiner's assertion that the Yamamoto et al., charged co-dopants Al, Ga, In, or N function in the same manner as the applicant's isoelectronic co-dopants is incorrect.

Dopants from a different Group (column) on the Periodic Table, as used by Yamamoto et al., have different numbers of valence electrons than the host lattice cation or anion elements, which they replace in the host lattice. Therefore, such dopants from different Groups than the host cations or anions, which they substitute, ionize in the host lattice at room temperature, which creates a net positive or a net negative charge, and they function in an entirely different manner than isoelectronic dopants, which are in the same Group and have the same number of valence electrons as the cations or the anions of the host lattice.

Thus, the isoelectronic co-dopants recited in applicant's claims 151 and 166 (same number of valence electrons as anion or cation they replace in host lattice) do distinguish this invention structurally over Yamamoto et al. (different number of valence electrons as anion or cation in host lattice). Therefore, claims 151 and 166 are not anticipated by Yamamoto et al., under 35 U.S.C. § 102(b), and they are not obvious under 35 U.S.C. § 103(a). Consequently, the examiner is requested to withdraw his rejections and to allow these claims 151 and 166.

Re: Claims 144, 160, 173:

The examiner cited co-doping of InP by Yamada et al. to reject applicant's claims 144, 160, 173, all of which claims recite, *inter alia*, ***isoelectronic co-doping*** of InP with both a ***deep acceptor and a deep donor***. However, while Yamada et al. do show co-doping of InP, and they do show doping with ***only a deep acceptor*** (N), Yamada et al. ***do not show*** co-doping with ***both***

a deep acceptor and a deep donor to get a lower effective bandgap than the InP has prior to such modification. Thus, applicant's claims 144, 160, and 173 are not anticipated by Yamada et al., under 35 U.S.C. § 102(b), and, contrary to the examiner's assertion, Yamada's co-dopants (N and B) ***do not*** function the same as the applicant's co-dopants in InP.

The examiner appears to be under the mistaken impression that the terms "deep acceptor" and "deep donor" have no structural distinctiveness as recited in applicant's claims 144, 160, and 173 and that Yamada et al. also lowered the effective bandgap of their InP lattice with their dopants. On the contrary, these terms "deep acceptor" and "deep donor" are defined and quantified in the specification (see, e.g., paragraph [0059]), and none of the co-dopants used by Yamada et al. meets this definition of "deep donor". Also, Yamada et al. reported their effective bandgap ***going up, not down***. Therefore, Yamada et al. does not anticipate applicant's invention under 35 U.S.C. § 102(b), and applicant's invention recited in claims 144, 160, and 173 are not obvious under 35 U.S.C. § 103(a).

Specifically, Yamada et al. only discuss co-doping with boron (B) and nitrogen (N), both of which are very small (at the top of their respective Group III and Group V in the Periodic Table) and very electronegative. The Yamada et al. co-doping with N does meet the "deep acceptor" recited in applicant's claims, but ***the B used by Yamada et al.*** in their co-doping ***does not*** meet the ***"deep donor"*** recited in applicant's claims, as "deep donor" is defined in paragraph [0059] of the specification. While Yamada et al., did also implant P^+, As^+, Sb^+, and Bi^+ ions ***singly*** into InP to show it could be done with the ion implantation technique, ***none of*** those elements ***P^+ As^+, Sb^+, and Bi^+ were co-doped*** in InP by Yamada et al. Thus, Yamada et al. ***did not*** show, teach, or suggest the "co-doping" with both a "deep acceptor" and a ***"deep donor"*** as recited in applicant's claims 144, 160, and 173.

Also, as mentioned above, ***instead of*** getting a ***lower effective bandgap***, as recited in applicant's claims, Yamada at el. reported emission extending ***far above*** the bandgap of InP, when the InP was dual implanted with N and B. This result implies, and Yamada et al. infer, that it is due to the fact that a ternary alloy, $(InP)_{1-x}$ $(BN)_x$ is formed. Since the bandgap of BN is very large, it results in ***an increase*** in the ternary alloy $(InP)_{1-x}$ $(BN)_x$ bandgap over the bandgap of InP itself for $x > 0$. This ***increase of the bandgap*** of $(InP)_{1-x}$ $(BN)_x$ over the bandgap of InP alone, as reported by Yamada et al., is ***directly opposite*** to the ***applicant's decrease in the bandgap*** of InP by isoelectronically co-doping with both a "deep acceptor" element and a "deep donor" element. The Yamada et al. N acts as a "deep acceptor", but the B implanted by Yamada et al. along with the N ***is not a "deep donor"***, thus causing an ***increasing*** bandgap ***instead of*** a ***decreasing*** bandgap.

While the applicant believes the recitation of "deep donor" in claims 144, 160, and 173 is sufficient itself to define this invention over Yamada et al., the recitation of the lower bandgap, already recited in claim 144, is being added to the recitations of claims 160 and 173 to distinguish them even more clearly over Yamada et al. Therefore, claims 144, 160, and 173 as amended are clearly distinguishable and allowable over Yamada et al. under both 35 U.S.C. §§ 102(b) and 103(a).

Re: Claim 119:

Claim 119, which is already allowed, is amended to correct a typographical error.

CONCLUSION

All of the previously rejected claims 85, 144, 151, 160, 166, and 173 are believed to be allowable under both 35 U.S.C. §§ 102(b) and 103(a) for the reasons explained above. Therefore, the examiner is requested to withdraw the previous rejections of those claims and to grant an early allowance. If any issues remain to be resolved, the examiner is requested to contact applicant's attorney at the telephone number listed below.

Respectfully Submitted,

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